INSTRUCTION REPORT S-69-6

LANDING MAT OVERLAYS ON DETERIORATED LANDING MAT OR PAVEMENTS

by

C. D. Burns
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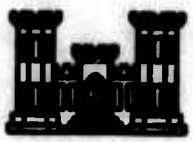

June 1969

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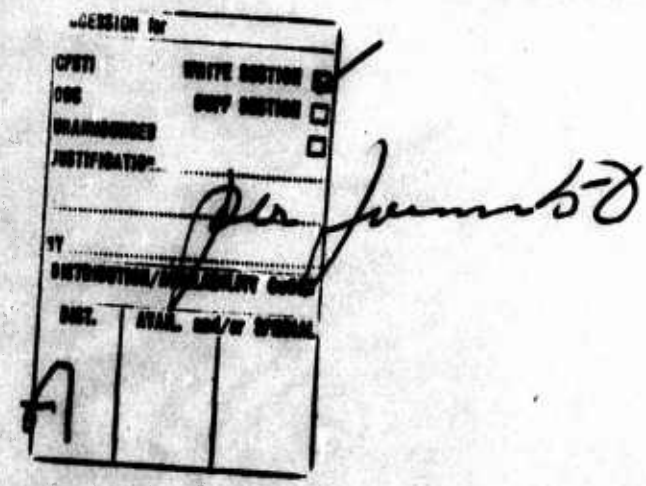

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FOREWORD

This manual was prepared as part of the work performed by the U. S. Army Engineer Waterways Experiment Station (WES) for the U. S. Air Force under the general project title of Bare Base Support. The work from which this manual was developed was authorized by USAF MIPR AS-7-203 dated 6 April 1967.

Engineers of the WES Soils Division who were actively engaged in the planning, testing, and analyzing phases of the Bare Base study were Messrs. W. J. Turnbull, A. A. Maxwell, R. G. Ahlvin, C. D. Burns, and W. N. Brabston. This report was written by Messrs. Burns and Brabston.

Director of the WES during the preparation of this manual was COL Levi A. Brown, CE. Mr. F. R. Brown was Technical Director.

CONTENTS

LANDING MAT OVERLAYS ON DETERIORATED LANDING MAT OR PAVEMENTS

INTRODUCTION

Purpose

1. This manual provides instruction and guidance for the design, construction, and maintenance of a landing mat overlay that can be built over a smooth but inadequate strength pavement or over a deteriorated landing mat or pavement surface in order to provide a suitable landing facility for the operation of tactical aircraft.

Scope

2. This manual presents general overlay concepts and describes construction and maintenance procedures.

Related Criteria

3. Where tactical time limitations will permit, the engineer should make use of criteria presented in the following publications:

a. Department of the Air Force and the Army, "Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations," AFM 86-3/TM 5-330.

b. Department of the Air Force and the Army, "Control of Soils on Military Construction," AFM 88-52/TM 5-541.

c. Department of the Army, "Planning and Design for Rapid Airfield Construction in the Theater of Operations," TM 5-366.

DESIGN

General Considerations

4. Overlay construction will normally be planned to upgrade an existing airfield facility that is of inadequate strength or that has deteriorated to such an extent that the surface roughness of the runway or taxiway precludes operation of tactical aircraft (photographs 1 and 2). A runway having a smooth surface but inadequate strength may be improved by placing the overlay mat directly over the pavement; however, placement of new landing mat directly on an irregular, unyielding surface would result in point loading and early failure of the new mat under traffic. Thus, it is necessary to construct a layer or cushion of soil over the deteriorated surface in order to provide a smooth seating surface for the new mat. Conceptually, the overlay would appear as shown in fig. 1. Specific design considerations include the following:

a. Grade and slope requirements.

b. Type and stability of the material proposed for use as the cushion material.

c. Design thickness of the soil cushion.

Fig. 1. Basic concept of soil-mat overlay construction (cross-sectional view)

d. Mat placement configuration.

Grade and Slope

5. The overlay should be constructed with a minimum crown or slope of 2.5 percent in order to facilitate drainage. If inadequate slope exists, it should be created in the soil layer. Once the slope has been determined, the design elevation of the finished overlay can be established based on the desired compacted thickness of the soil cushion.

Soil Type and Stability

6. Practically any type of soil, except the organic materials, can be used in overlay construction of this type. However, as with any landing-mat-over-soil system, certain precautions must be taken to prevent deterioration of the compacted soil underlay in wet weather. For example, it is known that during wet weather conditions, water will permeate the joints of landing mat. If the underlying soil is not protected, the material will become saturated, and the saturated soil will liquefy and pump up through the mat joints under traffic. Pumping action of this type can result in large voids under the mat and subsequently lead to premature failure. When the soil cushion is constructed of a fine-grained soil or a sand, it is recommended that a waterproof membrane covering be placed on the soil layer after grading and prior to placement of the new mat. Typical membranes to be used are T16, T17, and WX18, all of which are neoprene-coated nylon fabric materials. Further data on these membranes are indicated in table 1. It should be noted that at the present time, only

T17 is a standard military stock item. Some other heavy membranes are available and would be satisfactory for this use, provided an adequate adhesive is employed. Light membranes, such as those used to protect building materials, would be inadequate for this application. With either soil, special precautions should be taken to remove any large particles from the soil surface before placement of the membrane in order to prevent puncture as a result of point loading under traffic.

7. Pit-run clay gravel can also be used to construct the overlay cushion. However, this material cannot be protected from water intrusion with membrane due to the severe abrasive effect of the aggregate on the membrane as traffic is applied to the overlying mat. It has been found, however, that a clay gravel cushion can be stabilized very satisfactorily with portland cement. Other chemical stabilizers are also available that reduce the susceptibility of clay gravel to water intrusion. Various methods for stabilizing soils are outlined in detail in TM 5-330.

Thickness of Soil Cushion

8. The design thickness of the soil cushion will depend on the existing grade, severity of the surface roughness, and irregularities in the facility to be overlaid. However, the optimum thickness of the soil layer is considered to be the thickness, after compaction, that will (a) provide a minimum of 1 in. of soil cover over the most prominent surface irregularities, (b) allow enough soil that the material can be easily compacted and graded with available construction equipment, and (c) provide for a transverse slope or crown of at least 2.5 percent.

9. A design thickness in excess of the optimum may be used in any soil except unstabilized sand. Natural sand is quite susceptible to lateral shifting under traffic, resulting in bridging and inadequate support of the mat. Thus, if a sand cushion is contemplated, the design thickness should be strictly governed by the criteria indicated in paragraph 8.

Overlay Mat

10. The overlay may be surfaced with any type of landing mat; however, with the perforated mats such as M8, it will be extremely difficult to maintain stability of an underlying soil layer during wet weather unless the material has been chemically stabilized. In addition, the corrugated mats of this type, including M8A1, should be well seated in the soil layer in order to minimize mat creep under aircraft traffic. The solid surface mats, such as XM18, XM19, XM20, and AM2, are considered to be the best type of mat for overlay construction; however, a modified placement configuration should be used when laying 2- by 12-ft matting on a runway or taxiway having a crowned surface. This configuration is described in paragraph 11.

Mat Placement Configuration

11 The placement configuration of new overlay mat will be of concern only if the surface being overlaid has a crown and 2- by 12-ft landing mat is used. To facilitate placing 2- by 12-ft landing mat on a crowned surface, it is recommended that a configuration similar to that shown in fig. 2 be used. In this method, half panels, i.e. 2- by 6-ft panels, are

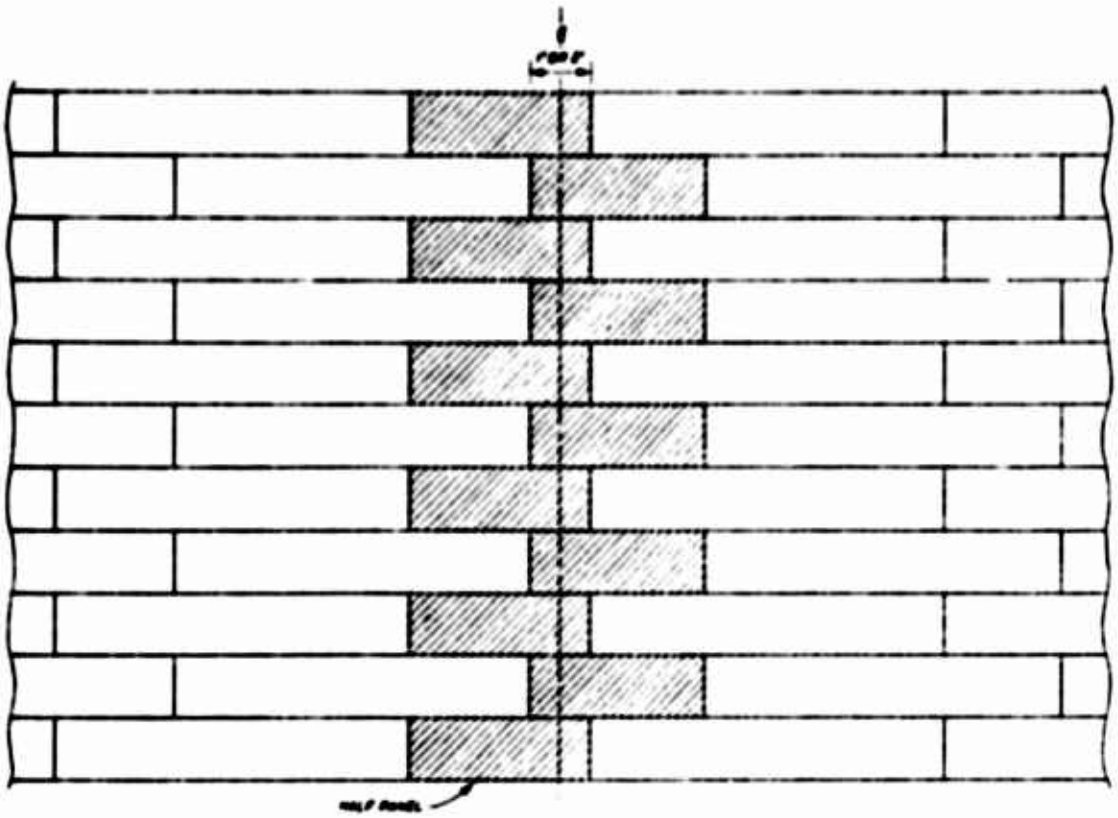

Fig. 2. Placement pattern for 2- by 12-ft landing mat over a crowned surface

used in the area of the center-line crown. The panels are placed so that the end joints on either side of the center line are staggered approximately 6 to 12 in., i.e. the half panels overlap approximately 1 to 2 ft. This configuration provides flexibility in the center-line area and has been proven to allow a much faster laying rate on a crowned surface than the conventional brickwork pattern. The end joint should overlap at least 6 in. in order to prevent the diagonally opposing corners of the plank in adjacent panels from creeping and overriding during traffic, and to provide joint stability in this area. An overlap in excess of 12 in. would, on the other hand, reduce the flexibility in the center-line area; thus the 6-12 in. overlap is considered to be optimum with respect to placement and performance under aircraft traffic.

CONSTRUCTION

12. Specific construction methods will vary slightly depending on the type of soil that is used for the overlay cushion. Therefore, descriptions of construction techniques are presented under three general categories of soil type: fine-grained soils, sands, and gravels.

Fine-Grained Soils

13. Prior to placing the soil on the deteriorated surface, the material should be processed to a water content at or slightly below the CE 12* optimum moisture content in order to obtain maximum density during compaction. The soil can be placed directly on the deteriorated surface and spread evenly with a dozer (photograph 3). Apply the maximum compaction feasible (photograph 4). If cracks develop in the soil layer during compaction as a result of high deflection in the deteriorated undersurface (photograph 5), the effects of additional compaction should be observed closely in order to avoid the development of soft areas and depressions in the overlay from pumping of the underlying structure. After compaction, the soil overlay must be graded to the desired elevation in order to provide a smooth seating surface for the new mat (photograph 6).

14. The membrane is then placed directly on the graded surface (photograph 7). Membrane sheets are manufactured to any specified size; however, the T17 is provided in sheets to accommodate a runway approximately 60 ft

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* CE 12 laboratory compaction is defined in MIL STD 621A and is equivalent to the standard AASHO laboratory compaction.

wide, and each sheet is approximately 100 ft long. Thus, a lateral joint will be required every 100 ft to ensure continuity of the membrane.

15. The membrane joints are made by overlapping adjacent sheets at least 12 in. in the joint area, applying cement to the areas on each membrane that will overlap (photograph 8), and, after the cement becomes tacky (5-15 minutes), pressing the cemented surfaces together and rolling a light vehicle over the joint several times to facilitate bonding. The cemented joint should be allowed to cure; maximum strength should be reached in about 24 hours. Any of the cements listed in table 2 can be used with the neoprene-coated membranes.

16. The finished membrane should be of sufficient width to extend at least slightly beyond both sides of the landing mat, and preferably should extend into the drainage ditches alongside the runway in order to minimize the chances of the soil cushion being exposed to runoff water. If the membrane extends beyond the mat more than 1 or 2 ft, the edge should be pinned to the ground or anchored in a trench in order to prevent uplift by wind or airblast from aircraft engines. If the overlay is constructed on a one-way slope, it will probably be necessary to anchor the membrane in a trench on the elevated side of the runway or taxiway in order to prevent saturation of the soil cushion as a result of cross-drainage down the slope. The construction of membrane anchor ditches is explained in detail in TM 5-366.

17. After the membrane has been laid, the landing mat is placed using the configuration recommended in paragraph 10 or 11 (photograph 9).

18. A small overlay test section, which was constructed by using the methods described in the preceeding paragraphs, is shown in photograph 10.

Sand

19. An overlay cushion can also be made with a sand material; however, the layers should be relatively thin, as indicated in paragraph 9. The sand should be placed directly on the deteriorated surface and compacted with a dozer (photograph 11) in order to reduce later densification. The sand surface can be smoothed with hand tools or a drawn land leveling apparatus to provide a smooth seating surface (photograph 12). Membrane can then be placed directly on the sand cushion using the methods described in the preceeding paragraphs, and new mat installed over the membrane.

Clay Gravel

20. Construction of a soil cushion with clay gravel involves a somewhat different approach than construction with sand or fine-grained materials in that the soil must be chemically stabilized and no membrane is used. Tests at the WES have indicated that if unprotected natural clay gravel is used for the soil cushion in a landing mat overlay, the fines in the soil will pump up through the mat joints under traffic in wet weather causing large voids in the soil layer. Further tests indicated that heavy membrane, such as WX18, cannot successfully protect the soil from water intrusion due to the abrasive action of the clay gravel on the membrane as aircraft traffic is applied to the overlay mat and that subsequent leakage develops

through the membrane into the soil. Chemical stabilization with 6 percent portland cement was found to provide a stable and reasonably water-resistant clay gravel layer.

21. The gravel may be placed and spread using the methods described earlier. After the clay gravel has been placed in the deteriorated surface, bags of cement can easily be spotted over the soil by means of a string grid (photograph 13). Each square on the grid defines the area over which one bag of cement is to be distributed in order to obtain the desired soil-cement ratio. For example, suppose that it is desired to stabilize an overlay of clay gravel with cement at 6 percent by soil weight and that the soil will have an average dry density of 130 pcf and an average thickness of 6 in. after compaction. Each 94-lb bag of cement will thus accommodate approximately 1567 lb of soil, which equals an area of approximately 24 sq ft of the soil overlay. Therefore, after the loose material has been placed, the cement would be spotted at the rate of one bag on each 24 sq ft of soil.

22. After the cement has been spotted to obtain the correct soil-cement ratio, each bag should be opened and the cement spread over the soil in each respective area. The cement can be mixed into the soil by means of small portable tillers (photograph 14) or large construction machines (photograph 15), depending on the thickness of the soil layer. After mixing, the clay gravel layer should be compacted and graded (photograph 16). The landing mat can then be placed directly on the stabilized soil cushion.

Construction Sequence

23. Overlay construction on a runway or taxiway should be accomplished sequentially in areas 300 to 500 ft long. As soon as one 300- to 500-ft strip of overlay soil has been placed, compacted, and covered with membrane or stabilized, construction can begin on the adjacent 300- to 500-ft-long strip; and mat laying can be initiated on the overlay just completed. This sequence should be followed until the entire runway or taxiway has been completed. This method of construction is proposed and the limitation of 300- to 500-ft-long areas is recommended in order to avoid exposing unduly large areas of the overlay soil to the elements of weather before the material is stabilized or covered. Obviously, if it were attempted to construct an overlay cushion several thousand feet in length at one time and the material were to become inundated due to sudden rainfall, the results would be disastrous; whereas the loss of a shorter length of overlay would be less severe.

24. In any event, this type of construction requires that certain precautions be taken in order to minimize the loss of any processed soil due to water saturation in the event of rainfall. First, the construction should be undertaken only during periods when relatively dry weather is anticipated. Secondly, all stockpiled soil should be protected by membrane covering or by shaping and sealing with a few coverages of a light compactor.

MAINTENANCE

25. Maintenance to the overlay soil cushion generally will only be required with membrane-protected soils when the membrane covering develops leakage and the underlying soil pumps up through the mat (photograph 17). To repair the membrane and soil, first remove the overlying mat. The membrane should be inspected carefully to determine location of cuts or holes through which the leakage occurred (photograph 18). Once these areas have been detected and marked, cut a flaplike opening in the membrane to expose the soil cushion (photograph 19). Remove all wet material and replace it with dry soil, which should then be compacted well. Replace the membrane flap and patch the access slits and leak hole by cementing pieces of membrane over these areas. Replace the landing mat on the membrane.

Table 1

SURFACE MEMBRANE DATA SHEET

	WES Designation		
	T16	T17	WX18
Description	Nylon fabric, neoprene coated	Nylon fabric, neoprene coated	Nylon fabric, neoprene coated
Ply	1	2	4
Weight (psf)	0.13	0.33	0.44
Size available	Must be specified	Runway 100 by 60 ft; taxiway 100 by 30 ft	Must be specified
Shelf life	Not determined	Not determined	Not determined
Cost (per square foot) 1968	$0.26	$0.50	$1.08
Source:			
U. S. Government	None	Commander Defense Construction Supply Center ATTN: DCSC-DT/CC Columbus, Ohio 43213	None
Federal stock no.*	None	Runway kit: 5680-921-8730 Taxiway kit: 5680-921-8731	None
Commercial**	Reeves Bros., Inc. 1071 Avenue of the Americas New York, N. Y. 10018	Reeves Bros., Inc. 1071 Avenue of the Americas New York, N. Y. 10018	Reeves Bros., Inc. 1071 Avenue of the Americas New York, N. Y. 10018
	Uniroyal, Inc. 407 N. Main St. Mishawaka, Ind. 46544	Uniroyal, Inc. 407 N. Main St. Mishawaka, Ind. 46544	Uniroyal, Inc. 407 N. Main St. Mishawaka, Ind. 46544
	Firestone Tire & Rubber Co. 1200 Firestone Parkway Akron, Ohio 44317	Firestone Tire & Rubber Co. 1200 Firestone Parkway Akron, Ohio 44317	Firestone Tire & Rubber Co. 1200 Firestone Parkway Akron, Ohio 44317

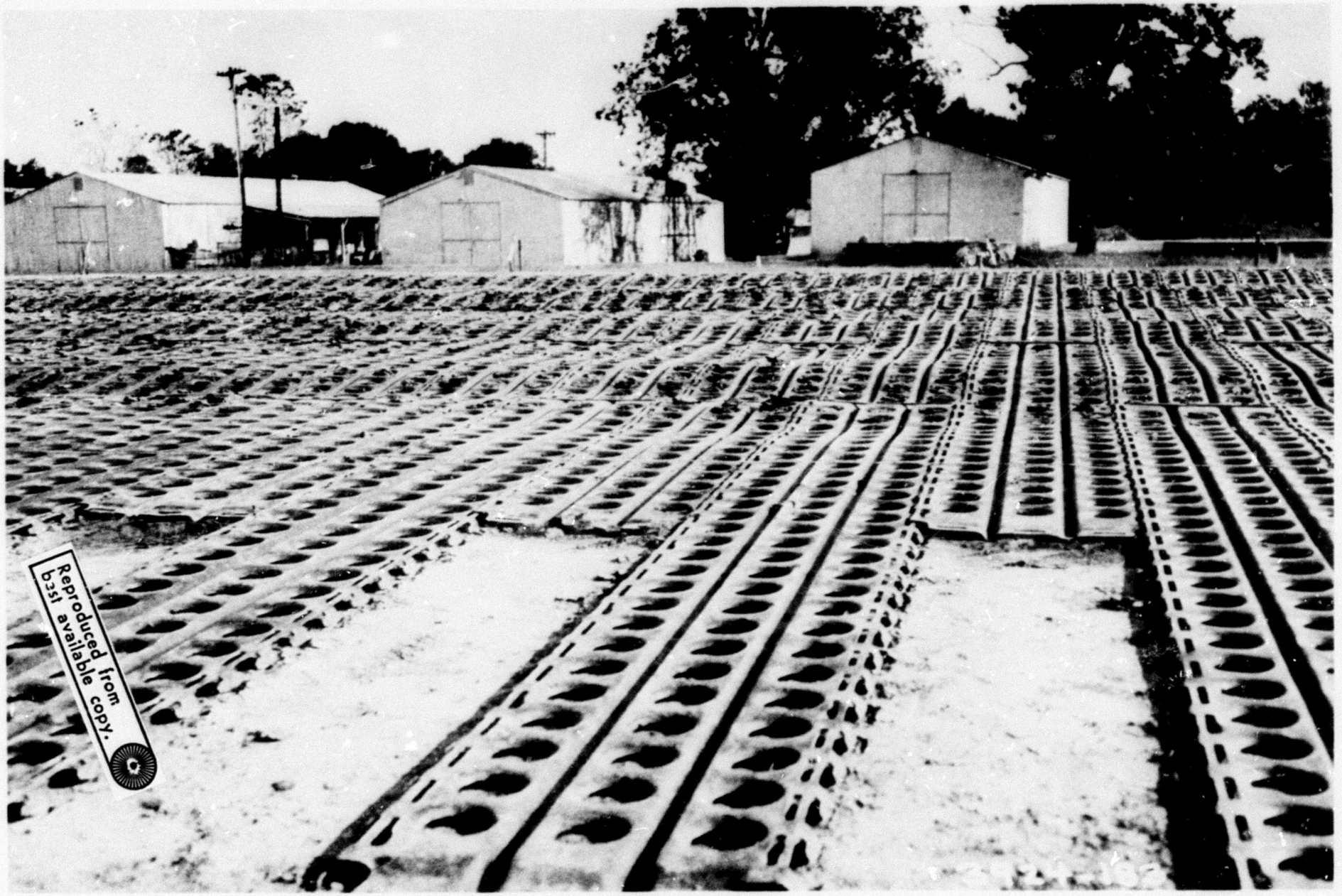
* The Federal stock nos. apply to complete kits. Each kit contains one large sheet of membrane plus the ancillary material for placement, e.g. cement, anchors, antiskid compound, etc. The commercial sources will supply only the membrane sheet unless other contract agreements are made.

** Commercial sources of membrane cements are given in table 3.

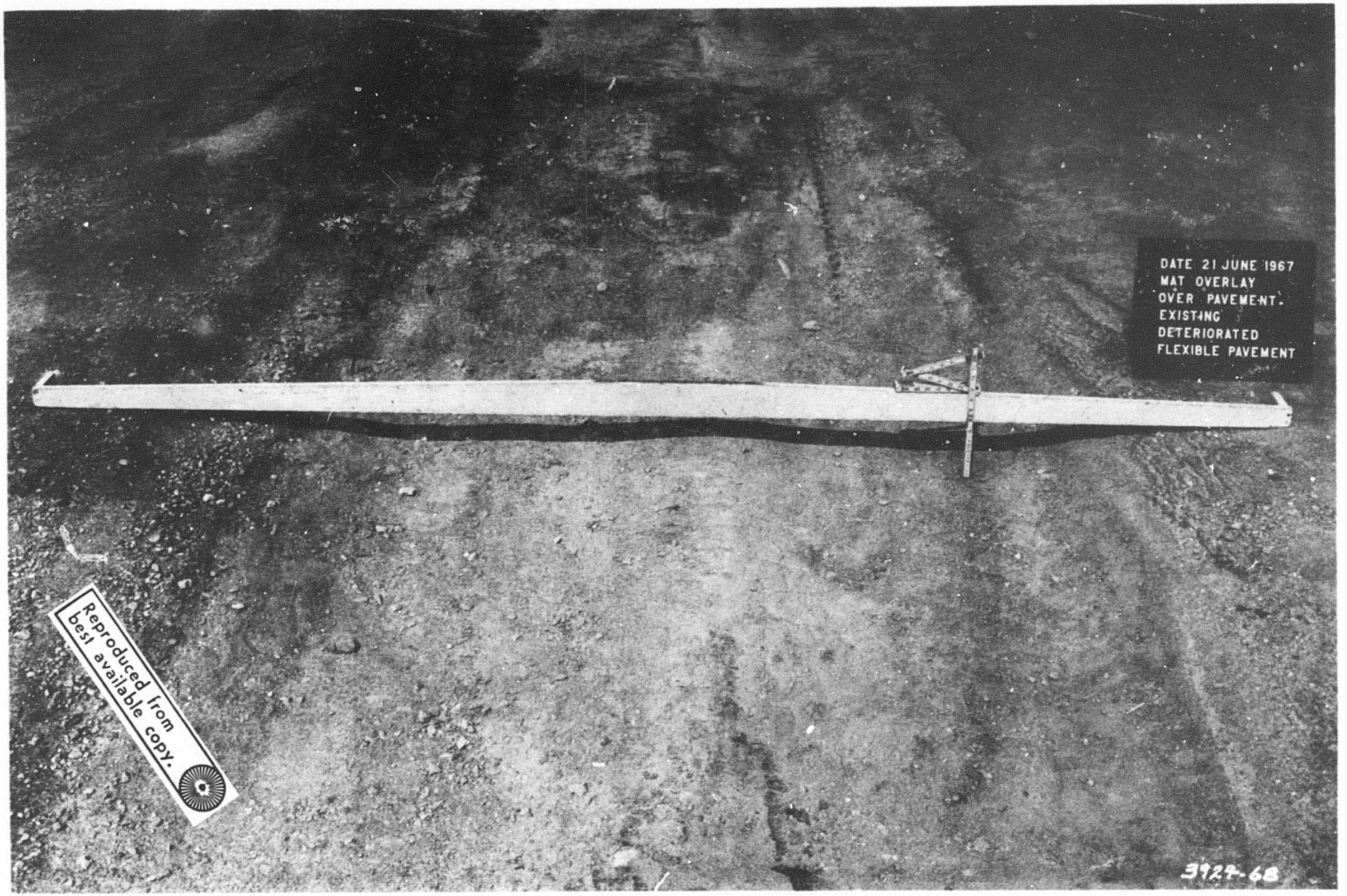
Table 2

COMMERCIALLY AVAILABLE MEMBRANE CEMENTS
(NEOPRENE-COMPATIBLE)

Manufacturer	Manufacturer's Designation
Pittsburgh Plate Glass	Bondmaster G 580-25 G 580-20 G 701 G 472
Minnesota Mining & Manufacturing Co.	EC 1711 2141 880
Taylor Adhesive Corp.	CON-TAC 1139
USM Chemical Co.	Bostik 1142



Photograph 1. View of a typical deteriorated landing mat surface



Photograph 2. View of a typical deteriorated pavement surface

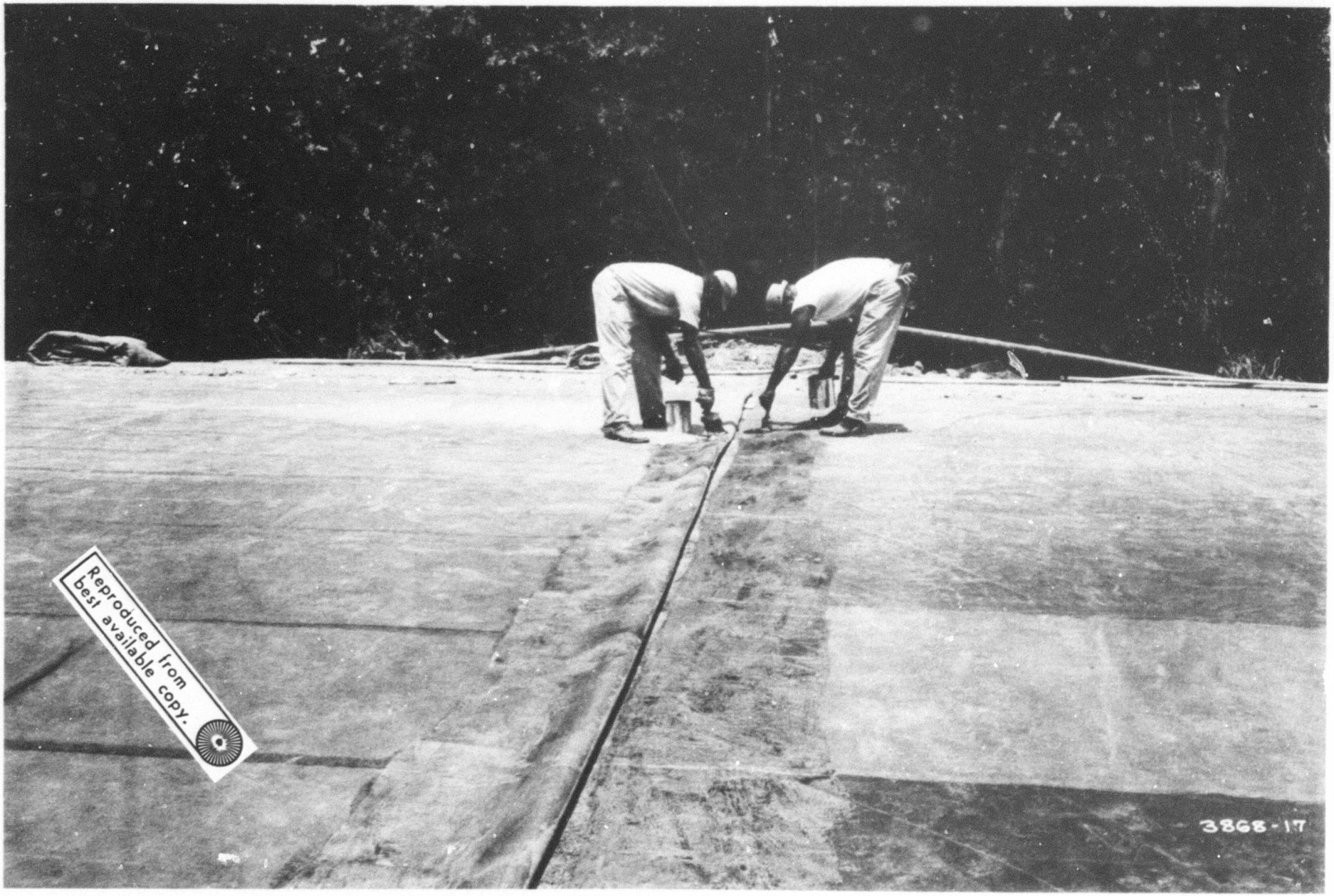
Photograph 3. Dumping and spreading soil for cushion over landing mat

Photograph 4. Compaction of soil cushion

Photograph 5. Cracks, developed during compaction of soil cushion, caused by pumping of the underlying structure

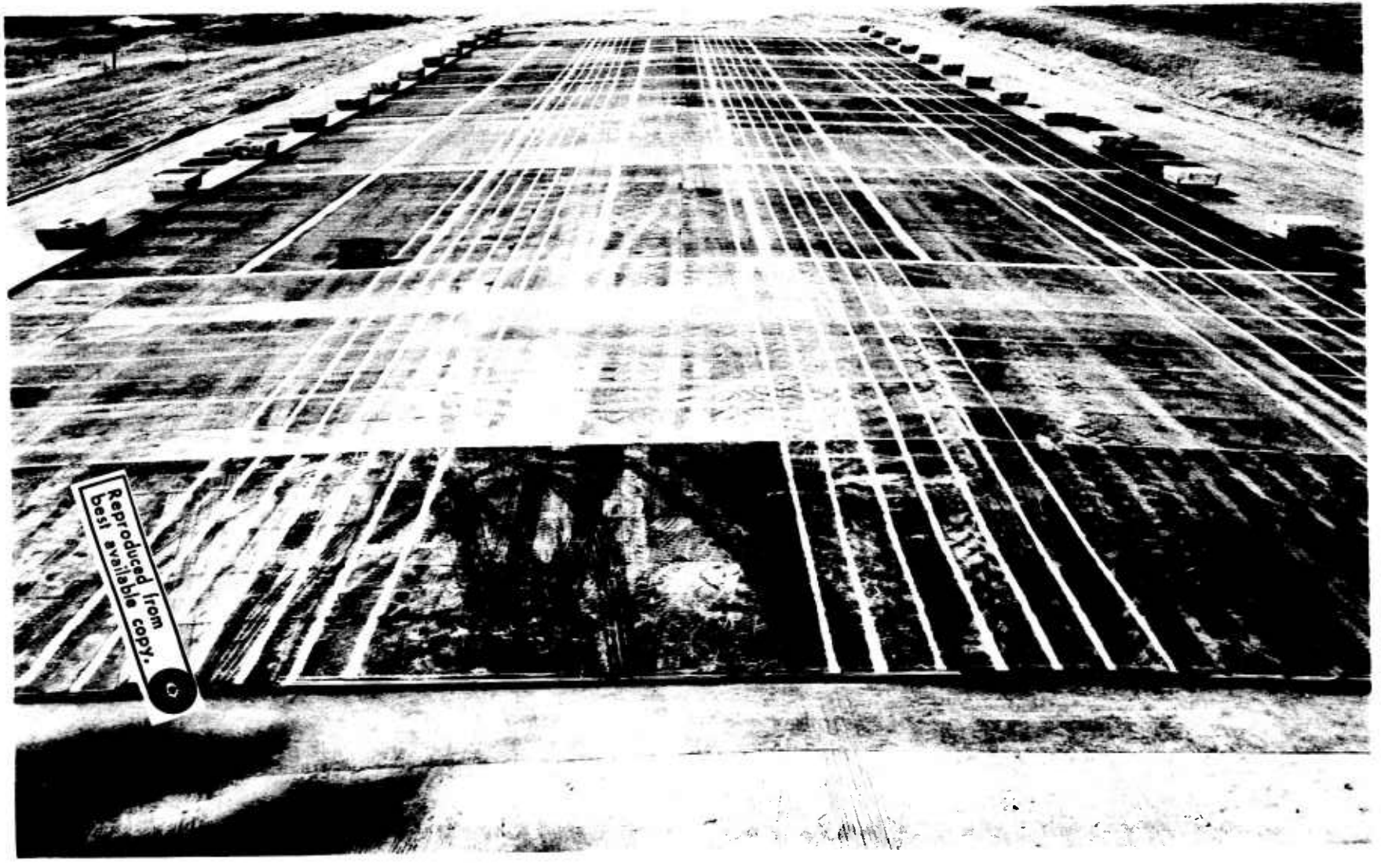
Photograph 6. Grading soil cushion

Photograph 7. Membrane in place over soil cushion



Photograph 8. Applying cement for lateral joint in membrane

Photograph 9. Mat placement over membrane



Photograph 10. Example of mat-soil overlay construction

Photograph 11. Compaction of sand for overlay cushion

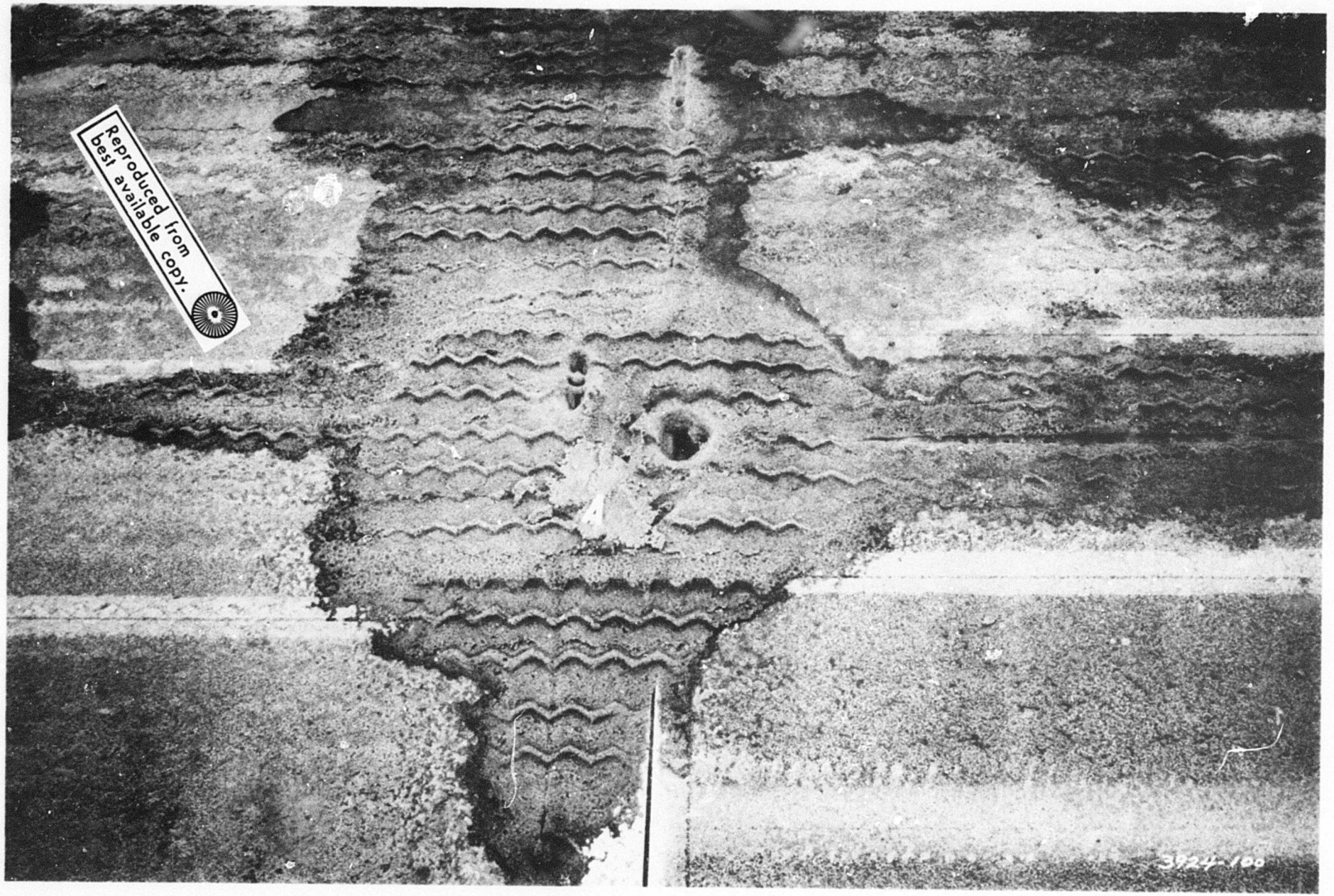
Photograph 12. Completed smooth sand overlay cushion

Photograph 13. Bags of cement deployed to guide distribution in desired proportions

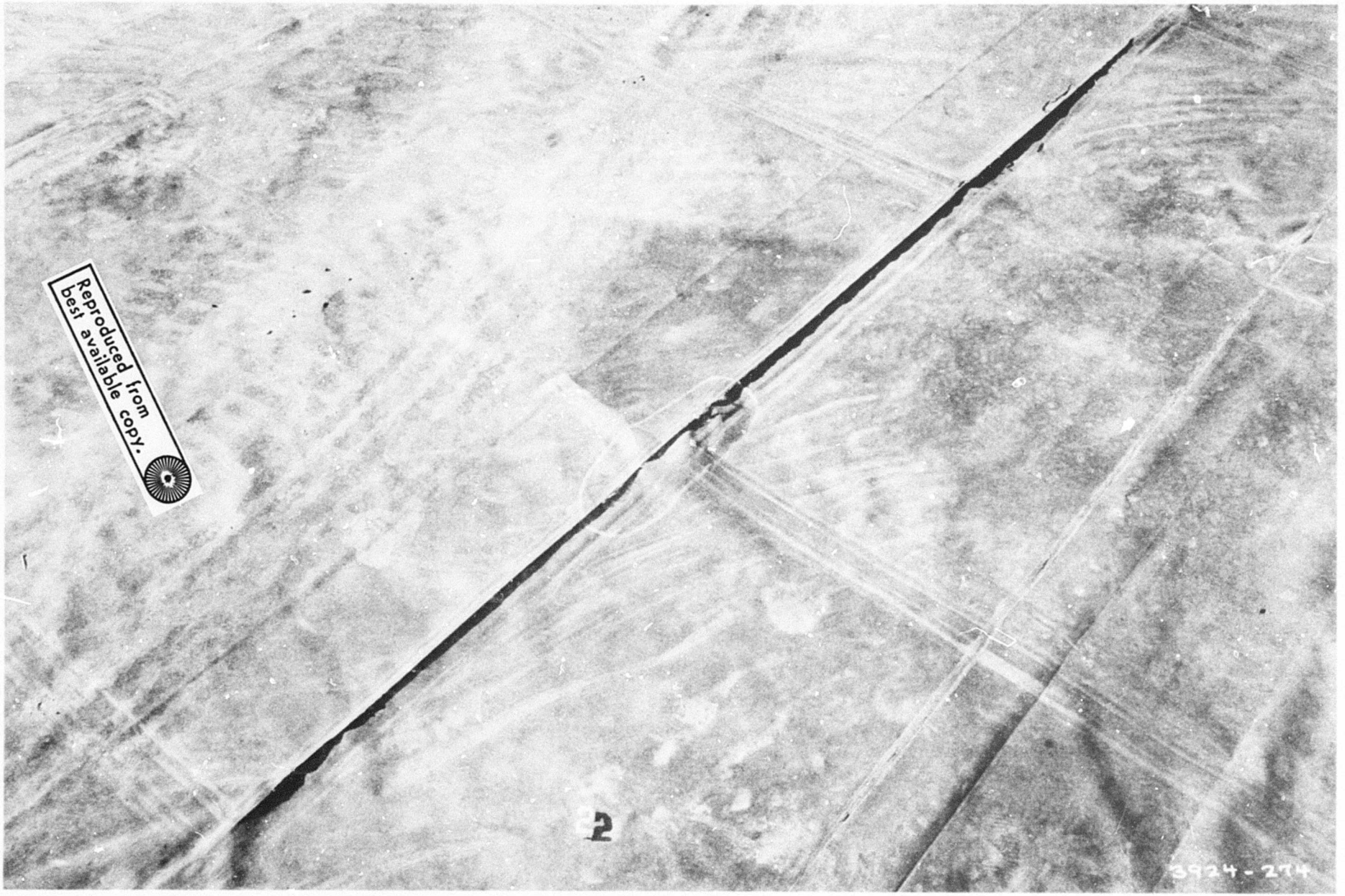
Photograph 14. Use of a portable small rotary tiller to mix cement into soil

Photograph 15. Using large construction equipment to mix cement into soil

Photograph 16. Compaction of stabilized clay gravel



Photograph 17. Soil pumped up through mat after puncture of membrane



Photograph 18. Open seam in membrane that must be repaired

Photograph 19. Exposure of wet soil resulting from penetration of water through membrane. (Note flap of membrane turned back in upper left.)